STUDIES OF THE TERRESTRIAL ENVIRONMENT AND AMBIENT AIR QUALITY IN THE VICINITY OF THE ELDORADO RESOURCES LTD. REFINERY AT BLIND RIVER, ONTARIO 1981-1987

AUGUST 1989

Environment Ontario

Jim Bradley
Minister

ISBN 0-7729-5214-0

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NORTHEASTERN REGION

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TABLE OF CONTENTS

STUDIES OF THE TERRESTRIAL ENVIRONMENT AND AMBIENT AIR QUALITY IN THE VICINITY OF THE ELDORADO RESOURCES LTD. REFINERY AT BLIND RIVER, ONTARIO 1981-1987

I Summary

In 1981, the Ontario Ministry of the Environment initiated a program to obtain background data on soils and vegetation in the vicinity of the Eldorado Resources Ltd. (ERL) uranium refinery prior to the operational start-up of the complex. A total of 7 plot sites were selected where 20 trees of each of trembling aspen and white pine (where available) were tagged, measured and evaluated annually for condition and growth. Soil and vegetation (foliage of white pine, trembling aspen and grass) samples have been collected annually for chemical analyses at these sites between 1981-1987. A separate collection was made in 1985 at 4 of the plot sites which included foliage of several plant species as well as 1, 2 and 3 year old needles of white and red pine. A collection of a variety of wild edibles were collected in 1986 in the vicinity of the refinery.

All samples were analyzed for 11 elements: uranium, copper, nickel, lead, cobalt, zinc, iron, sulphur, calcium, magnesium and potassium. Of the elements tested, only uranium showed an increase in concentration in foliage samples collected in close proximity to the refinery (on ERL property) following the start-up of the facility in the summer of 1983. The highest uranium content found in annual vegetation (exposed for approximately 3 months) and soil samples was 14.67 and 2.57 ug/g, respectively.

An accumulation of uranium took place in red and white pine needles. The highest level of uranium found in red pine needles that were exposed for 3 years was 100 ug/g. Uranium levels found in all soil and wild edible samples were considered normal.

The increase of uranium content over time in the collected vegetation samples indicates deposition from the refinery is being retained in annual vegetation and accumulated in conifers. Since uranium levels are low in the soil, the levels in vegetation result mostly from deposition and not uptake. Plants may accumulate high concentrations of uranium relative to background and not show symptoms of phytotoxicity. Vegetation in the vicinity of the refinery is generally healthy and no phytotoxic effects from the refinery have been noted. The situation warrants continued monitoring to ensure that the deposition of uranium from the ERL refinery will not pose any adverse environmental impact.

The Ontario Ministry of the Environment also initiated a high volume sampling program in the community of Blind River in 1982, to determine if the Eldorado Resources Ltd. operations would have any affect on the levels of suspended particulates and their associated radiological burden in ambient air.

High volume filters were collected on a six-day schedule from a monitor on the roof of St. Joseph's Hospital commencing in August of 1982. Filters were weighed to determine total suspended particulate loadings and were sent to the Ministry of Labour's Radiation Protection Laboratory for radiological analyses. Radiological analyses included total uranium, thorium ^{228}, radium ^{226}, gross alpha and beta.

Total suspended particulate levels were low with no values above the Provincial criteria of 120 ug/m^3 for 24 hours and 60 ug/m^3 for an annual geometric mean being observed. No increase in particulate loadings were observed in Blind River since operations at Eldorado Resources Ltd. began in the summer of 1983.

Analyses for radiological parameters indicate low levels of total uranium, thorium ^{228}, radium ^{226}, gross alpha and gross beta in suspended particulate. An increase in radiological parameters is not evident since the uranium refinery began operations in 1983.

II Introduction

In 1978, the proposal by Eldorado Resources Ltd. to build a uranium hexafluoride refinery in Ontario was subjected to environmental assessment hearings. Three possible sites for the refinery were selected for review, and the site at Blind River was finally selected.

The original proposal was that the refinery would produce uranium hexafluoride (UF_6). Subsequent to the decision that the refinery would be built at Blind River, it was decided that the new refinery would produce only the intermediary product, uranium trioxide (UO_3), at a rate of 18,000 tonnes per year. Operations began in the summer of 1983.

As part of the overall surveillance program to determine whether emissions from the refinery would affect the environment, the Ontario Ministry of the Environment initiated a variety of monitoring surveys prior to the start-up of operations. In 1981, a network of permanent tree plots were established in the vicinity of the refinery, and samples of vegetation were collected for chemical analyses. Preliminary results of this program have been documented in a previous report (McIlveen & Negusanti, 1985). This sampling program has been continued, and the present report covers results obtained in both the pre-operational and post start-up periods.

The Ministry also carried out ambient air quality monitoring in the community of Blind River as part of the overall surveillance program.

A high volume monitor was co-located with one operated by Eldorado Resources Limited on the roof of St. Joseph's Hospital in Blind River in August of 1982. Filters from the site have been analysed for total suspended particulate at the Ministry of the Environment laboratory in Toronto and for radiological parameters (total uranium, thorium ^{228}, radium ^{226}, gross alpha and gross beta) at the Ministry of Labour's Radiation Protection laboratories also located in Toronto.

Air quality data presented in this report summarize data collected from August of 1982 to December of 1987.

III Permanent Vegetation Plots

i) Plot Establishment

In August, 1981, following a visual reconnaisance of the area, six sites were selected for establishment of permanent vegetation plots. A seventh site, to act as a control was added in 1983. These sites are shown in Figure 1 and are located, with respect to the refinery, as follows:

Plot Number	Location
1	100 m NW
2	200 m NE
3	1200 m NE
4	300 m S
5	900 m ESE
6	2400 m ENE
7	10 km E (Control)

Four of the plots are located on property controlled by ERL, and three of these are in close proximity to the fence around the complex. Public access across the property is available to the golf course, situated northwest of the refinery, and to the park area near Patrick Point.

At each plot, 20 semi-mature trembling aspen (Populus tremuloides) were selected for monitoring purposes. White pine (Pinus strobus) was available in sufficient numbers only at Plots 1, 3 and 4. Each of the selected trees was identified with a numbered metal tag held in place with a copper nail. The diameter at breast height (DBH) was measured and recorded, and the measurement height was marked on each tree with a band of paint.

ii) Plot Evaluation

In late August each year, the trees were evaluated for the following parameters: crown condition, foliar colour (for white pine), insect injury and disease. Crown condition ratings were expressed as a numerical rating from 1 to 6 for hardwoods: 1 being a very healthy tree exhibiting excellent form, growth, colour, whereas a rating of 6 represented a dead tree. Descriptions of the crown classification systems used for conifers and hardwoods are shown in Tables 1 and 2, respectively.

Foliar colour of white pine was also numerically rated. Each white pine was assigned a foliage colour class rating from 1 to 10 matched against colour standard cards: 1 being a very dark green with increasing rating values becoming progressively lighter green, through a chlorotic or yellow range until brown necrotic foliar colour is present at the rating of 10.

Insect damage and disease were classified using five injury categories based on leaf area affected (Table 3).

All trees were re-evaluated in August, 1982, 1983, 1984, 1985 and 1986. It was discovered that the plot at Site 1 had been destroyed during the construction of a golf course; therefore, a new Plot 1 was established approximately 100 m south of the original in August, 1983. A control plot (Plot 7) was selected at a location 10 km east of the refinery in 1983. The same techniques were employed during the establishment of the two new plots.

iii) Results

a) Diameter and Growth Rates

A summary of the size and growth measurements of the trees is presented in Table 4. In the first year of establishment, the mean plot DBH ranged from 14.6 cm to 27.9 cm for trembling aspen and 13.9 cm to 32.1 cm for white pine.

Annual diameter increment was quite variable for both species at all plots between 1981-1986. Growth was lowest in 1983 at all sites, attributable to the exceptionally dry conditions which prevailed that growing season. There was no discernible trend relating diameter growth with proximity to the refinery.

b) Crown Condition

Crown condition ratings are presented in Table 5. Trembling aspen has shown a decline in crown condition at each plot, including the control plot.

Hypoxylon canker, a common serious disease of trembling aspen is believed to be the major contributing factor to this crown deterioration. The incidence of this disease has substantially increased since plot establishment.

The four white pine plots exhibited only slight differences in average crown condition ratings between initial year of establishment and 1986.

There was no apparent association between crown condition of either white pine or trembling aspen with proximity to the refinery.

c) Foliar Colour

The numerical colour rating of white pine foliage, as estimated using colour chips, is presented in Table 6. Average ratings varied between 4.0 and 5.0 for all plots from (1981-1985). Foliar colour estimations are of a subjective nature and no significant trend could be determined in relationship to distance from the refinery.

d) Insect Damage and Disease

Insect injury to trembling aspen was recorded in each year of evaluation. Severity, mainly rated as light, appeared to decline in the first years and has remained relatively stable at all plots since 1983 (Table 7).

The following diseases and mortality were noted:

Species	Plot	Mortality	Hypoxylon Canker	Phellinus Heart Rot	Leaf Spot	Ink Spot
Aspen	1	0	0	1	17	0
	2	0	3	0	0	0
	3	0	2	0	1	0
	4	1	8	1	0	0
	5	2	9	2	0	1
	6	1	5	0	6	0
	7	0	8	2	0	0

No relationship between either insect damage or disease and proximity to the refinery was evident. As mentioned previously, the crown deterioration noted in the trembling aspen plots is thought to be a direct result of the spread of Hypoxylon canker.

IV Vegetation and Soil Sampling Program

i) Sampling Procedures

In August of each year (1981-1987), when the tree plots were evaluated, triplicate samples of vegetation foliage (white pine, trembling aspen and forage grasses) and soil (0-5 cm) were collected at each plot location. In 1985, additional samples of foliage of white birch, pin cherry, willow, beaked hazel, bracken fern, white pine and red pine were collected from all plots in which they were present. White pine and red pine needles were divided into current year's growth, 1984 needles and 1983 needles.

In 1986, in anticipation of public concerns regarding picking wild edibles in the vicinity of Eldorado, a sampling program was undertaken. Samples of bunchberry, wintergreen, chokecherry, blueberry and crabapple were collected where possible in the vicinity of the plant. These locations are shown in Figure 2. Blackberry fruit was collected at the control site (Plot 7).

Vegetation samples were placed in plastic bags, sealed using a twist tie and placed in coolers with cold packs. These samples were processed at the Ministry of the Environment laboratory in Sudbury. Vegetation samples were oven-dried, ground in a Wiley mill and placed in glass jars. The soil samples were air-dried, ground with a mortar and pestle to pass through a 45 mesh sieve and bottled. The samples were then delivered to the laboratory in Toronto for uranium analysis.

ii) Results and Discussion

a) Uranium

The concentrations of uranium in vegetation and soils are presented in Tables 8, 9 and 10. Although no guidelines have been established by the Ministry of the Environment for normal levels of uranium in soil or vegetation, data are available from other sources for comparison purposes (Table 11).

Concentrations of uranium in foliage of vegetation (Table 8) have increased at all sites near the refinery since the start of operations in 1983, with the exception of Site 6, 2400 m east northeast. Greatest increases have occurred at Sites 1, 2 and 4, all of which are within 300 m of the refinery. Only minor accumulations were noted at the other sites with no impact discernable at a distance of 2400 m.

Concentrations of uranium in the current year's foliage showed little variation between species (Table 9). Trembling aspen, white birch and beaked hazel seemed to have slightly higher uranium content in comparison to pin cherry, willow and bracken fern. This may be related to leaf size with the former species having more leaf surface to collect deposition. Grass samples had the highest uranium content of the annual species. This could be partially due to grass

growing in more exposed areas, where it is not as sheltered as plants situated in a closed forest stand. In red pine and, to a lesser extent, white pine, a buildup of uranium occurred in the older needles. At Site 2, 200 m to the northeast of the refinery, two year old red pine foliage had accumulated over 70 ug/g and three year old foliage over 100 ug/g of uranium.

Uranium levels found in wild edibles are shown in Table 10. Low levels of uranium were measured in all samples. The highest uranium content was found in bunchberry samples (0.67 ug/g) at Site 2. After reviewing the data the Ministry of Labour reported that there does not appear to be any undue hazard with regard to the occasional consumption of these wild edibles.

Concentrations of uranium in the soil (Table 8) were all less than the expected natural background levels in soils as given in Table 11, and, from the data obtained to date, evidence of accumulation in soil was limited to those sites within 300 m of the source.

Similar studies conducted in the vicinity of the refinery at Port Hope have reported concentrations (Table 11) as high as 173 ug/g in maple foliage (McLaughlin, 1981) and 460 ug/g in the surface soil (0-5 cm) (McLaughlin, 1984). The highest levels of uranium found in foliage and surface soil (0-5 cm) collected in vicinity of Eldorado's Blind River operation were 14.7 ug/g and 2.6 ug/g, respectively.

iii) Phytotoxicity

Vegetation in the vicinity of the refinery is generally healthy and no phytotoxic effects from the refinery have been noted. Normal effects resulting from ground disturbance, insect and disease were encountered. The increase of uranium content over time in the vegetation collected in close proximity of the refinery indicates deposition is being retained in annual vegetation and accumulated in conifers. Since uranium levels are low in the soil (maximum of 2.6 ug/g), the levels found in vegetation are believed to be mostly from deposition and not uptake. It is highly unlikely that phytotoxic effects will result in plants via uptake from soil in the vicinity of the Blind River refinery at the present soil levels. Foliar uranium content resulting from direct deposition is not expected to produce any phototoxicological effects. Natural background uranium concentration in uncontaminated soils is 0.7 to 9 ug/g (Bowen, 1979). Plant uptake of uranium is usually very low because of strong adsorption by soils (Brown et al., 1983). Plants may accumulate high concentrations of uranium relative to background and yet not show symptoms of phytotoxicity (Brown et al., 1983). The minimum reported phytotoxic soil uranium concentration is 50 ug/g (inhibition of wheat growth, cited in Nishita et al., 1978). The phytotoxic soil uranium concentration for Scots pine seedlings is > 100 ug/g (Sheppard et al., 1985).

V Ambient Suspended Particulate Monitoring

i) Sampling Techniques

In August of 1982, a standard high volume sampler was installed on the roof of St. Joseph Hospital in Blind River (Station 71065, Figure 3). The sampler was co-located with one operated by Eldorado Resources Ltd.. The site was considered by both MOE and Eldorado Ltd. to be representative of the air quality in the community.

The high volume (hi-vol) sampling technique determines the mass concentration of suspended airborne particulate ($\leq$100 microns) by drawing a known volume of air through a pre-weighed filter medium (Figure 4). Standard operation of the sampler involves air flow rates from 0.9 to 1.4 m^3/minute and the use of a Gelman AE glass fibre filter. The sample is collected over a 24-hour period, midnight to midnight, every one, three or six days. The six-day operating schedule is pre-determined and is consistent throughout Canada and the United States. This six-day sampling is considered to be representative of the air quality over a year.

Two criteria for desirable air quality exist for total suspended particulate matter. One is 120 ug of suspended particulate per cubic metre of air averaged over a 24-hour period. The other is an annual geometric mean of 60 ug/m^3. The 24-hour criterion is based on impaired visibility and adverse health effects (in combination with sulphur dioxide), while the annual criterion is based on public awareness of suspended particulate and subsequent aesthetic effects.

High-volume samples may also be analysed for trace metals and compounds such as radiological parameters.

Glass fibre filters exposed at the St. Joseph's Hospital location were sent to the Ministry of the Environment's Toronto laboratory, where they were weighed to determine total particulate loadings and a portion of each filter was prepared and forwarded to the Ministry of Labour's Radiation Protection Laboratory for radiological analysis.

Radiological determinations included total uranium, thorium ^{228}, radium ^{226}, gross alpha and gross beta. These isotopes are part of the uranium and thorium decay series and are formed via various intermediate alpha and beta emitters in the series.

ii) Analysis Results

a) Total Suspended Particulates

Results of total suspended particulate (TSP) analyses on glass fibre filters collected in Blind River (Station 71065) from August of 1982 to December of 1987 are summarized in Table 22.

Total suspended particulate levels were low indicating little particulate contamination from anthropogenic sources. The provincial 24 hour criterion of 120 ug/m^3 was not exceeded during the entire period. The maximum 24 hour values measured between 1982-1987 ranged from 42 ug/m^3 to 115 ug/m^3 with the highest values being recorded in 1984. These higher 24 hour values are influenced by meteorological conditions and reflect normal activity in the Town of Blind River.

The yearly criterion of 60 ug/m^3 geometric mean was not exceeded at the Hospital site. Geometric means ranged from a low of 16 ug/m^3 in 1982 to a high of 24 ug/m^3 in 1984 and 1987.

b) Radiological Parameters

Tables 23 to 27 summarize results of radiological analysis for total uranium, thorium ^{228}, radium ^{226}, gross alpha and gross beta. The Ontario Ministry of the Environment does not have standards or guidelines for radiological parameters in ambient air. Samples are analyzed only to determine trends and in the case of Blind River, to determine if Eldorado Resources Ltd. operations have resulted in any increase in radiological parameters at the site.

Uranium:

Total uranium values in TSP were low (Table 23). Annual geometric means were at the detection limit of 0.001 ug/m^3 in 1982, 1983, 1984 and 1987. Geometric means of 0.002 ug/m^3 in 1985 and 1986 were only slightly above the detection limit. The slightly higher geometric mean from 1985 is a result of one value of 0.013 ug/m^3 collected in November of that year. The higher annual geometric mean in 1986 is a result of three individual readings which occurred in May, July, and August. The highest reading was 0.034 ug/m^3, observed in May of that year. Uranium levels in suspended particulate do not indicate any change in levels or trends from 1982 to 1987 at the Hospital site.

Thorium ^{228}:

Thorium ^{228} analyses were carried out on filters from 1982 to 1987 (Table 24). Thorium ^{228} levels were low with no values above the detection limits of 0.143 mBq/m^3 used before October 1985 and 0.043 mBq/m^3 after October 1985 being recorded during the survey.

Radium ^{226}:

Radium ^{226} levels in suspended particulate were low with the majority of samples being below the detection limit (Table 25). The detection limit for radium ^{226} was increased from 0.006 mBq/m^3 to 0.029 mBq/m^3 at the end of 1983, and the increase in the geometric mean from 1984 to 1987 reflects this change. The actual maximum values have decreased from 1982 to 1987, as have the number of readings above the detection limit. Because of the extremely low numbers (at or near the detection limit) being dealt with in this database, one must be cautioned that any changes from year to year are more a function of the analytical techniques than of the variations in environmental loadings.

Gross Alpha:

Table 26 summarizes the gross alpha data collected in Blind River from August 1982 to March 1987. As with other radiological parameters, variations from year to year reflect changes in analytical technique rather than actual environmental concentrations. The detection limits varied from 0.006 mBq/m^3 during the early part of the survey to 1.430 mBq/m^3 in late 1983 to 1987. On occasion, the

detection limit also varied for specific samples (1.14 mBq/m^3 and 0.383 mBq/m^3 in 1985). Almost all the samples collected were below the detection limit from 1984 to 1987 and one can assume that the majority if not all of the earlier samples would have been below the higher detection limit. The increase in annual geometric mean from 1983 to 1987 is a result of the variation in detection limit of a few values reflected in the maximum value column.

Gross Beta:

A summary of gross beta in suspended particulate is presented in Table 27. As with other radiological parameters, the majority of samples contained levels below the detection limits of 0.006 mBq/m^3 used before December 1983 and 1.430 mBq/m^3 used after that date. Geometric means increased after 1985 reflecting the increase in detection limits. The maximum value of 7.900 mBq/m^3 was observed in 1986.

*Any increase in geometric means reflects analytical procedure rather than ambient air quality.

VI Conclusions

1. Uranium concentration in foliage of vegetation has increased primarily up to a distance of 300 m from the refinery. Since the start of operation in 1983, minor accumulations in current years foliage were noted up to a distance of 1200 m from the refinery with no effect discernable at a distance of 2400 m.

2. Significant accumulations of uranium has occurred in 2 and 3 year old needles of red and white pine growing 200 m northeast of the refinery.

3. Since operation commencement, minor increases of uranium in surface soil have been measured up to 1200 m from the refinery. These values are considered within normal ranges of concentration.

4. Accumulation of uranium in vegetation is primarily due to deposition on the foliage from the refinery and not bio-uptake from the roots.

5. Diameter growth, crown condition and foliar colour measurements of the tree plots revealed no discernable relationship with proximity to the refinery.

6. The highest level of uranium found in wild edibles (bunchberry) in the vicinity of the refinery was 0.67 ug/g. This level is considered within a normal concentration range. The Ministry of Labour reported that there does not appear to be any undue hazard with regard to the occasional consumption of these wild edibles.

7. Crown condition rating in the trembling aspen plots deteriorated due to the increase of trees infected by Hypoxylon canker (a common serious disease of aspen).

8. Vegetation in the vicinity of the refinery is generally healthy and no phytotoxic effects from the refinery have been noted.

9. Present levels of uranium in the soil in the vicinity of the refinery are not expected to have a phytotoxic effect.

10. High volume samples collected at St. Joseph's Hospital from 1982 to 1987 indicate low levels of suspended particulate in the Community of Blind River.

11. Radiological parameters associated with suspended particulates were also low with the greater majority of values being below the analytical detection limit presently available.

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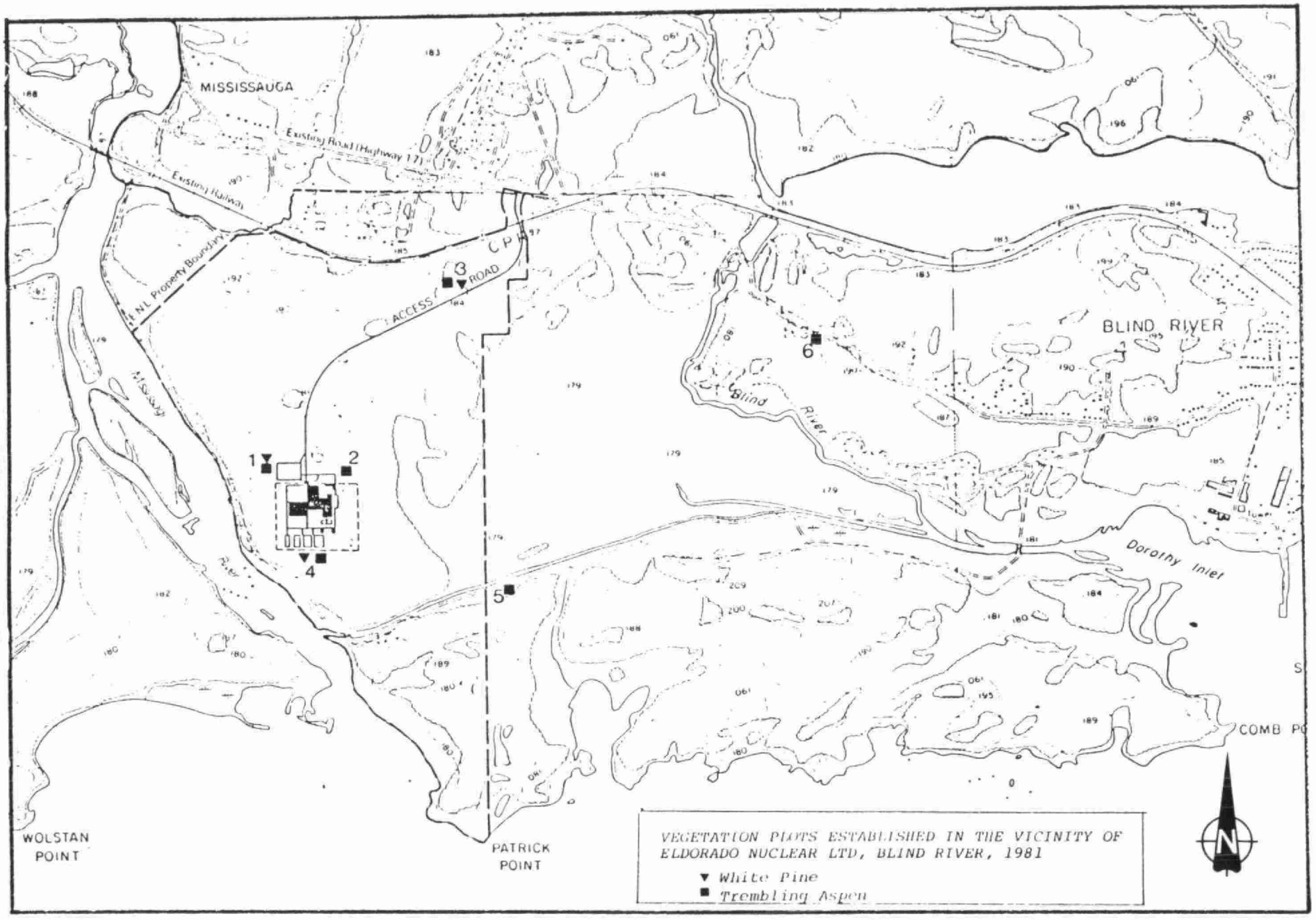
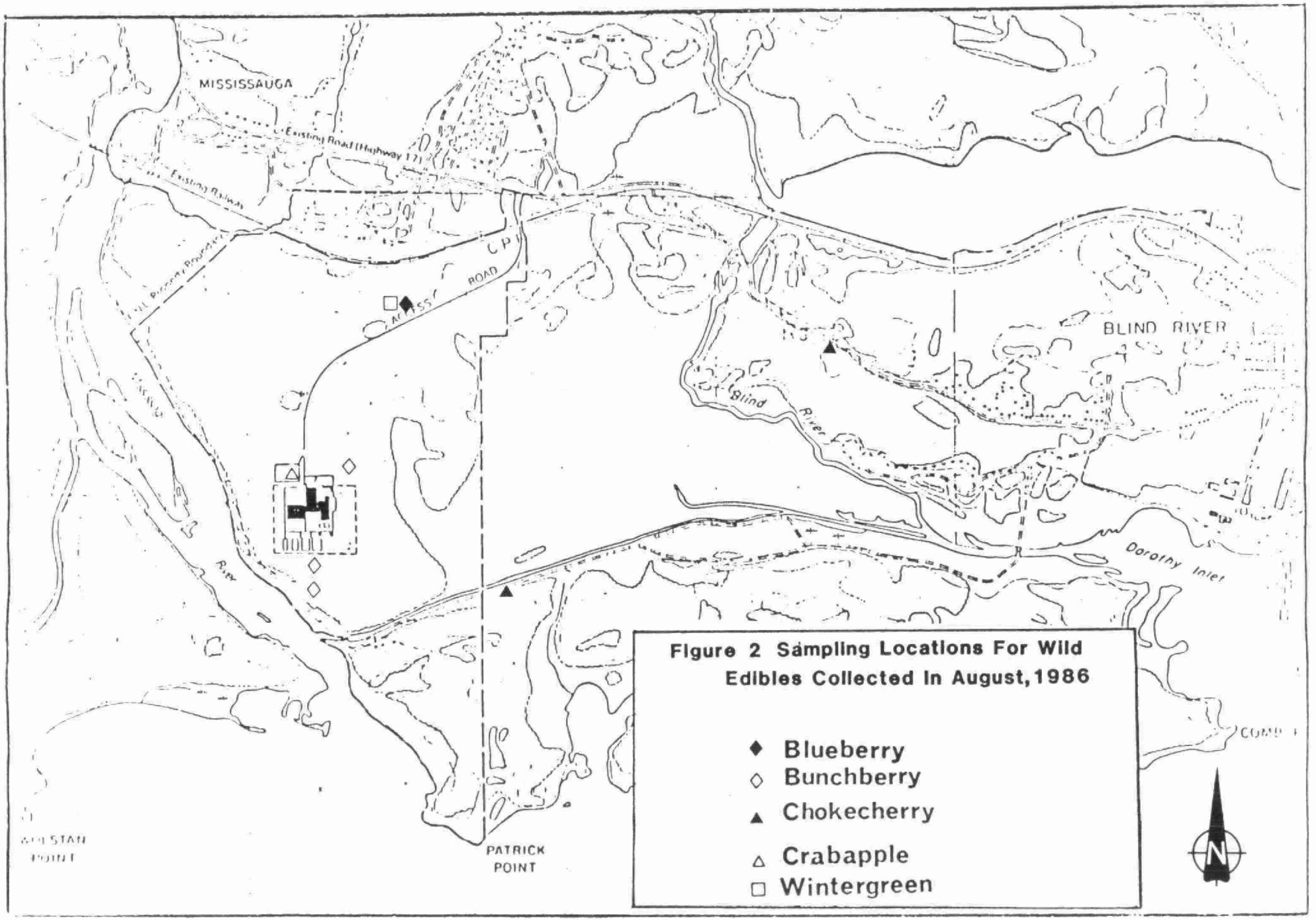
VIII Appendix

FIGURE 1


MISSISSAUGA
Existing Road (Highway 17)
Existing Railway
CNR
CPR
ACCESS ROAD
NL Property Boundary
BLIND RIVER
Blind River
Dorothy Inlet
COMB PO
WOLSTAN POINT
PATRICK POINT
1
2
3
4
5
6
VEGETATION PLOTS ESTABLISHED IN THE VICINITY OF ELDORADO NUCLEAR LTD, BLIND RIVER, 1981
White Pine
Trembling Aspen
N


MISSISSAUGA
Existing Road (Highway 17)
Existing Railway
C.P.R.
ACCESS ROAD
BLIND RIVER
Blind River
Dorothy Inlet
PATRICK POINT
Figure 2 Sampling Locations For Wild Edibles Collected In August, 1986
Blueberry
Bunchberry
Chokecherry
Crabapple
Wintergreen
N

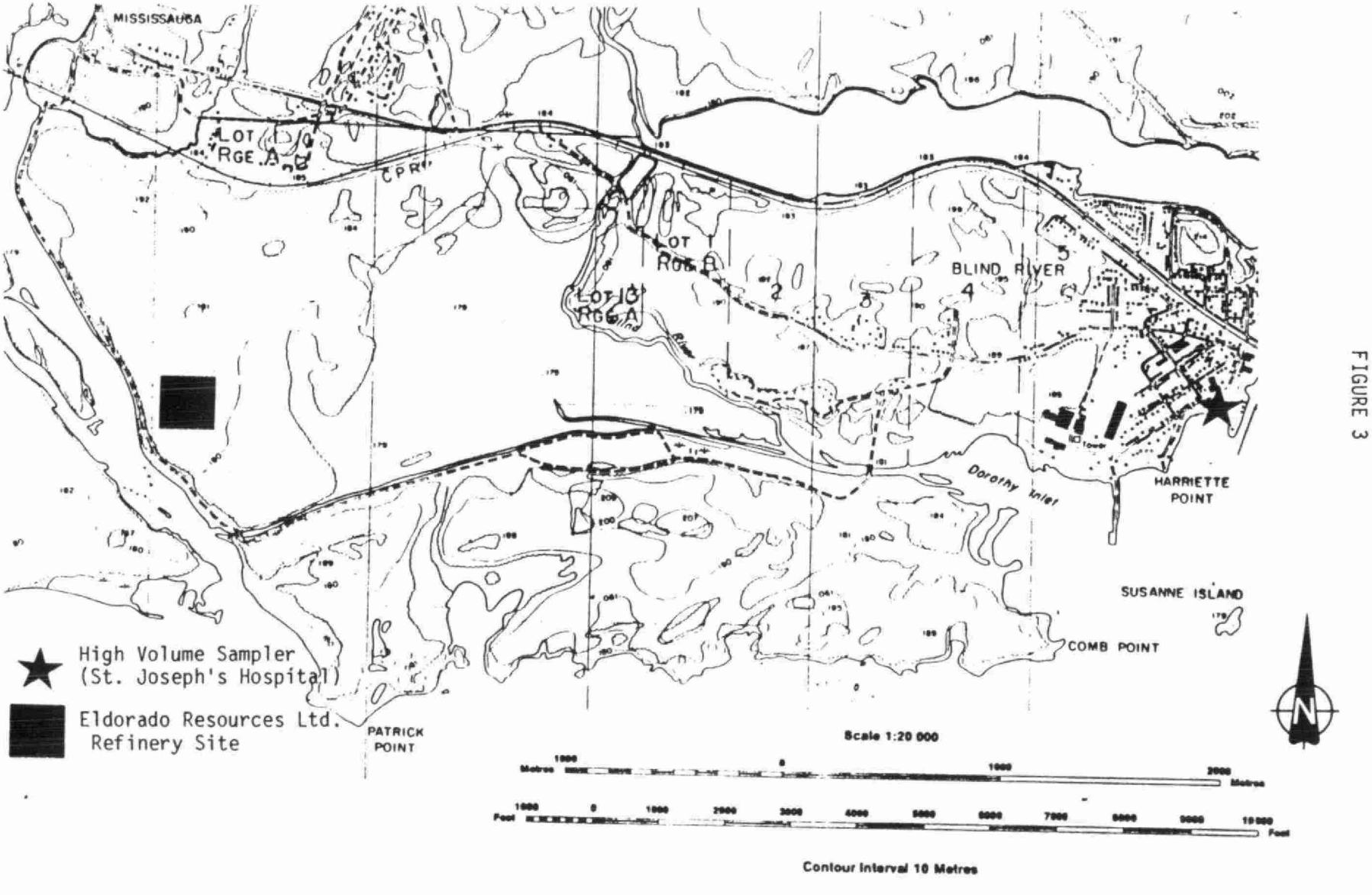

MISSISSAUGA
LOT
RGE A
CPR
LOT
RGE A
LOT 13
RGE A
BLIND RIVER
Dorothy Inlet
HARRIETTE POINT
SUSANNE ISLAND
COMB POINT
PATRICK POINT
High Volume Sampler
(St. Joseph's Hospital)
Eldorado Resources Ltd.
Refinery Site
Scale 1:20 000
Contour Interval 10 Metres

FIGURE 3

FIGURE 4

HIGH VOLUME AIR SAMPLER

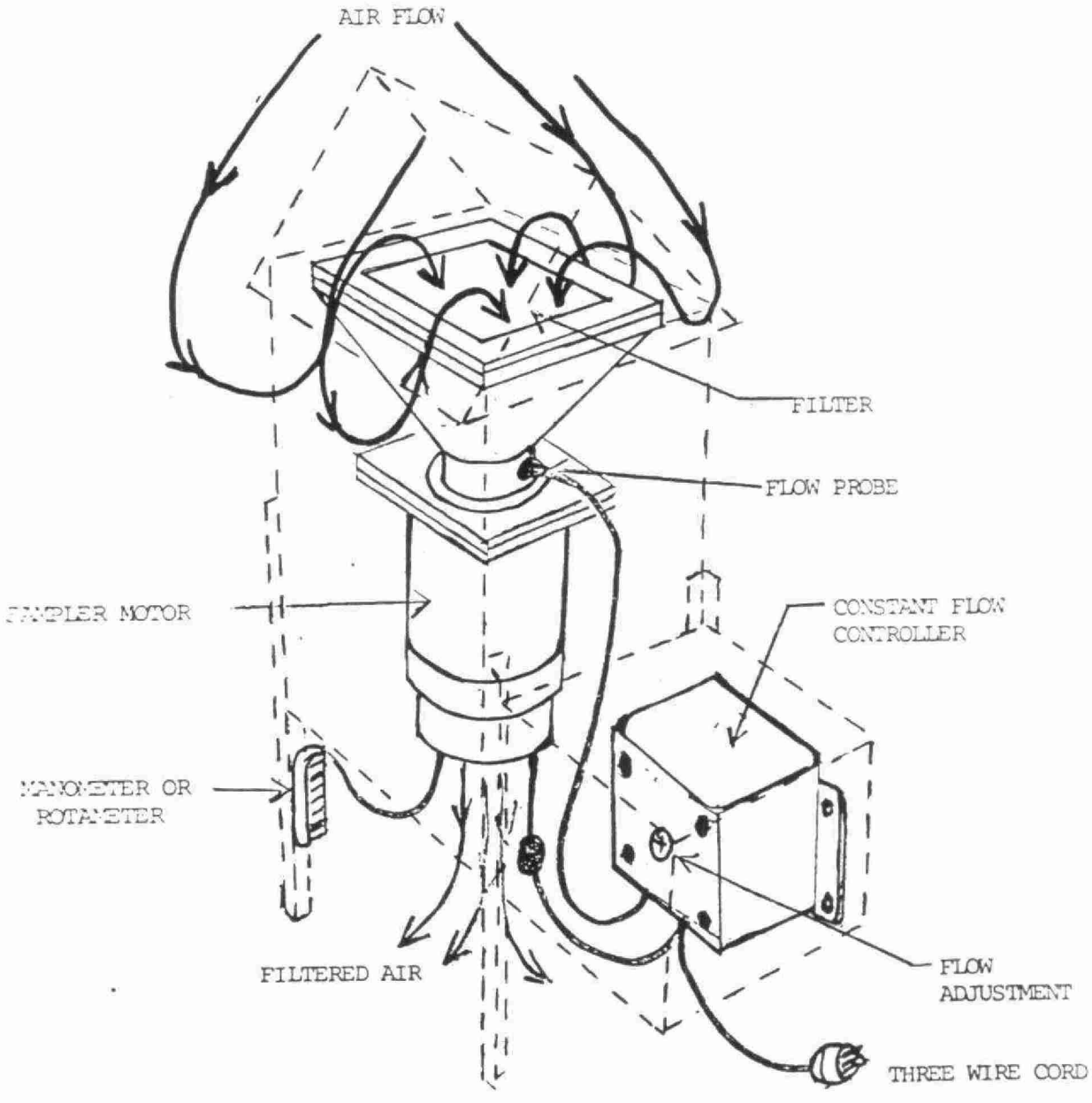


TABLE 1

Crown Condition Classification System for Coniferous Trees

Rating	Description
1	Near perfect specimen tree
2	High quality forest tree with self-pruning of shaded branches
3	Tree in good condition, may have one or two dead branches
4	Tree in fair to moderate condition with three or more dead branches
5	Up to one half of crown dead
6	One half to 75% of crown dead
7	75-90% of crown dead
8	Over 90% of crown dead, some branches retained foliage
9	Branches with few live needles/leaves still attached
10	Tree dead, branches still mainly intact

TABLE 2

Crown Condition Classification System for Deciduous Trees *

Rating	Description
1	Very healthy tree, foliage full size and rich in colour, no dead twigs or branches unless attributed to recent mechanical injury, tree displaying good growth and form
2	Healthy tree, foliage can be slightly smaller and more sparse than normal and slightly chlorotic, tree may have one dead branch or light dieback for no apparent reason, but such branches constituting less than 20% of the crown, tree shows good growth, but form may be slightly crooked
3	Fairly healthy tree, foliage may be noticeably small, sparse or chlorotic, tree may have three dead branches or dieback for no apparent reason, but such dieback constituting less than 40% of the crown, tree shows fair growth, and form may be moderately crooked or dwarfed, tree has a good chance to survive and improve
4	Unhealthy tree, foliage can be moderately to severely dwarfed and sparse, foliage colour moderately to severely chlorotic, tree with 40 to 80% of crown dead form may be severely crooked or dwarfed, tree has fair chance to survive or improve
5	Very unhealthy tree, main stem over 80% dead, most twigs still attached, foliage severely chlorotic, small, very sparse, tree has limited possibility of survival
6	Tree dead, no living tissue

* Adapted from Hawbolt system of hardwood crown classification, Canadian Forestry Service

TABLE 3

Leaf Injury Rating System
for Insect Damage and Diseases

Injury Category	% Foliar Injury (Area Basis)
Healthy	0
Trace	> 0 - 1
Light	2 - 10
Moderate	11 - 35
Severe	>35

TABLE 4

Summary of Diameter Growth* of Trees in Plots Established
in the Vicinity of the Eldorado Resources Uranium Refinery at Blind River

Species	Plot #	Location	Year of Establishment	DBH**	Annual Diameter Increment 1982	1983	1984	1985	1986
Trembling Aspen	1	100 m NW	1983	14.6	-	-	.72	.74	.54
	2	200 m NE	1981	18.7	.29	.05	.42	.51	.80
	3	1200 m NE	1981	16.2	.45	.02	.41	.50	.32
	4	300 m S	1981	20.0	.44	.04	.49	.52	.04
	5	900 m ESE	1981	24.8	.45	.24	.61	.83	1.48
	6	2400 m ENE	1981	16.0	.37	.21	.52	.39	.29
	7	10 km E	1983	27.9	-	-	.28	.52	.34
White Pine	1	100 m NW	1983	13.9	-	-	.34	.42	.21
	2	200 m NE	1981	-	-	-	-	-	-
	3	1200 m NE	1981	32.1	.31	.09	.18	.60	.24
	4	300 m S	1981	16.0	.32	.05	.24	.33	.32
	5	900 m ESE	1981	-	-	-	-	-	-
	6	2400 m ENE	1981	-	-	-	-	-	-
	7	10 km E	1983	18.3	-	-	.57	.67	.68

* All measurements reported as cm
** DBH - Average diameter at breast height

TABLE 5

Average Crown Condition Rating* of Trees in Plots Located
in the Vicinity of the Eldorado Resources Uranium Refinery at Blind River

Species	Plot #	Location	Mean Crown Condition Rating					
			1981	1982	1983	1984	1985	1986
Trembling Aspen	1	100 m NW	-	-	1.35	1.70	1.00	2.00
	2	200 m NE	1.05	1.30	1.21	1.60	1.75	2.30
	3	1200 m NE	1.00	1.10	1.60	1.40	1.45	2.50
	4	300 m S	1.05	1.15	1.50	1.50	1.37	2.30
	5	900 m ESE	1.15	1.30	1.95	1.94	2.61	3.90
	6	2400 m ENE	1.20	1.35	1.85	1.75	1.75	2.95
	7	10 km E	-	-	2.00	1.75	1.75	2.05
White Pine	1	100 m NW	-	-	-	3.25	3.10	2.80
	2	200 m NE	-	-	-	-	-	-
	3	1200 m NE	2.65	2.90	1.30	2.95	2.84	2.60
	4	300 m S	3.85	3.70	2.35	3.25	3.35	3.25
	5	900 m ESE	-	-	-	-	-	-
	6	2400 m ENE	-	-	-	-	-	-
	7	10 km E	-	-	2.10	2.85	2.95	2.05

*Rating is described in Table 1 for aspen and Table 2 for white pine.

TABLE 6

Average Foliar Colour Rating* of White Pine Trees
in Plots Located in the Vicinity of the
Eldorado Resources Uranium Refinery at Blind River

Plot Number	Location	1981	1982	1983	1984	1985
1	100 m NW	-	-	-	4.0	4.8
3	1200 m NE	4.7	4.6	5.0	4.1	4.7
4	300 m S	4.6	4.6	5.0	4.0	4.1
7	10 km E	-	-	5.0	4.0	4.2

*Colour class rating of foliage (1-10) are estimated from colour standard chips: 1 being a very dark green with increasing rating values becoming progressively lighter green, through yellowing shades until brown necrotic colour receives a rating of 10.

TABLE 7

Summary of Insect Severity Ratings for Trembling Aspen Plots
in the Eldorado Resources Uranium Refinery, Blind River

Plot #	Location	Year 1981	1982	1983	1984	1985	1986
1	100 m NW	light*	-	trace	light	trace	light - moderate
2	200 m NE	light	light	trace	light	trace	trace - light
3	1200 m NE	light - moderate	light	light	trace - light	trace - light	light
4	300 m S	light - moderate	light - moderate	light	light	trace - light	light
5	900 m ESE	light - moderate	light - moderate	light	light	light	light
6	2400 m ENE	light	light	trace - light	light	trace - light	light
7	10 km E	-	-	light	light	light	light

* Based on ratings from original plot

TABLE 8

Concentration of Uranium (ug/g)* in Vegetation and Soil Samples Collected in the Vicinity of the Eldorado Resources Uranium Refinery at Blind River - 1981 to 1987

Foliage Type	Site	Location	1981**	1982	1983	1984	1985	1986	1987
Trembling Aspen	1	100 m NW	0.009	0.04	0.25	1.33	1.73	2.09	8.10
	2	200 m NE	0.018	0.03	1.50	5.69	4.20	14.57	4.23
	3	1200 m NE	0.011	0.05	0.06	0.28	0.20	0.32	0.18
	4	300 m S	0.009	0.02	0.09	2.67	<.05	0.93	2.73
	5	900 m ESE	0.009	0.01	0.05	0.20	0.24	0.11	0.22
	6	2400 m ENE	0.009	<.01	0.03	0.06	<.05	0.03	<.05
	7	10 km E	-	-	<.02	<.05	<.05	0.01	<.05
White Pine	1	100 m NW	0.008	0.03	0.42	0.51	0.77	2.51	3.37
	2	200 m NE	0.031	0.05	1.32	2.91	2.65	7.29	4.60
	3	1200 m NE	0.046	0.04	0.05	0.06	<.05	0.42	0.09
	4	300 m S	0.013	0.01	0.13	0.52	0.19	0.72	1.93
	5	900 m ESE	0.008	-	0.03	0.16	<.06	0.15	0.13
	6	2400 m ENE	-	0.01	0.03	0.06	<.05	0.03	<.05
	7	10 km E	-	-	<.02	<.05	<.05	0.03	<.05
Forage	1	100 m NW	0.009	0.03	0.05	0.69	4.23	1.12	14.67
	2	200 m NE	0.014	0.05	1.05	2.44	5.31	6.85	12.17
	3	1200 m NE	0.013	0.01	0.06	1.24	0.24	0.31	0.23
	4	300 m S	0.033	0.01	0.14	1.08	1.80	1.95	3.73
	5	900 m ESE	0.013	<.01	0.05	0.10	0.11	0.11	0.34
	6	2400 m ENE	0.003	0.01	0.03	<.05	<.05	0.02	<.05
	7	10 km E	-	-	<.02	<.05	<.05	0.004	<.05
Soil	1	100 m NW	0.45	0.85	0.32	0.69	1.04	0.93	1.43
	2	200 m NE	0.57	0.45	0.35	1.16	1.35	1.00	2.57
	3	1200 m NE	0.01	0.31	0.25	0.55	0.90	0.41	0.90
	4	300 m S	0.02	0.55	0.54	0.80	0.85	0.65	2.37
	5	900 m ESE	1.60	1.58	0.93	0.57	1.97	2.42	0.76
	6	2400 m ENE	0.39	0.29	<.25	0.34	0.24	0.28	0.24
	7	10 km E	-	-	0.30	0.77	0.21	1.56	0.42

* Results are reported as the mean of triplicate samples

** 1981 samples were resubmitted for analysis due to better technology which lowered the detection limit to less than 1

TABLE 9

Concentrations of Uranium (ug/g) in Vegetation
Collected in the Vicinity of Eldorado Nuclear,
Blind River, Ontario
August 21, 1985

Foliage Type	Site Number						
	1	2	3	4	5	6	7
Trembling Aspen *	1.73	4.20	0.20	<.05	0.24	<.05	<.05
Grass *	4.23	5.31	0.24	1.80	0.11	<.05	<.05
White Pine 1983 *	1.70	13.81	0.32	1.23	0.52	0.07	<.05
White Pine 1984 *	1.37	11.57	0.17	0.49	0.29	0.33	<.05
White Pine 1985 *	0.77	2.65	<.05	0.19	<.06	<.05	<.05
Red Pine 1983	9.92	100.21	1.36	5.19	-	-	-
Red Pine 1984	3.55	70.88	0.97	4.67	-	-	-
Red Pine 1985	0.67	1.67	0.29	0.20	-	-	-
White Birch	-	4.63	0.17	1.24	-	-	0.05
Pin Cherry	1.47	2.61	0.07	0.98	-	-	0.05
Willow	0.83	3.62	0.10	1.01	-	-	
Beaked Hazel	3.01	4.00	0.07	0.69	-	-	0.05
Bracken Fern	1.49	2.30	0.05	0.21	-	-	0.05

* Results are reported as the mean of triplicate samples.
All other results are based on single samples.

TABLE 10

Concentrations of Uranium (ug/g) in Wild Edibles
Collected in the Vicinity of Eldorado Nuclear,
Blind River, Ontario, August 20, 1986

Species	Sampling Locations							
	50 m N	Site 2 200 m NE	Site 3 1200 m NE	Site 4 300 m S	400 m S	Site 5 900 m ESE	Site 6 2400 ENE	Site 7 10 km E
Blueberry *	-	-	0.04	-	-	-	-	-
Blackberry	-	-	-	-	-	-	-	0.07
Bunchberry **	-	0.67	-	0.28	0.06	-	-	-
Chokecherry **	-	-	-	-	-	0.02	0.01	-
Crabapple	0.19	-	-	-	-	-	-	-
Wintergreen	-	-	0.28	-	-	-	-	-

* Single samples
** Results are reported as the mean of 2 samples.
All other results are reported as the mean of triplicate samples.

TABLE 11

Uranium (ug/g) in Soil and Vegetation: Reference Data

Sample Medium	Mean	Range	Reference
(A) Soil			
- natural background	2.0	0.7-9.0	Bowen, 1979
- Port Hope veg. gardens (control)*	2.0	-	Tracey, et al.,1983
- Port Hope veg. gardens (contam.)**	-	7.5-420	Tracey, et al., 1983
- Phytotoxicology survey, Port Hope	-	0.7-460	McLaughlin, 1984
- Darlington Prov. Park	1.0	1.0	McLaughlin, 1981
- significant yield reduction of sensitive crops	-	50	Nishita et al., 1978
(B) Plants	--		
- natural background	-	0.005-0.06	Bowen, 1979
- Port Hope veg. produce (control)*	0.31	-	Tracey, et al., 1983
- Port Hope veg. produce (contam.)**	-	0.27-194	Tracey, et al., 1983
- Port Hope maple foliage	-	2.0-173	McLaughlin, 1981
- Darlington Prov. Park maple foliage	0.6	0.4-0.8	McLaughlin, 1981

*control gardens were based on radiation levels of 10 to 15 uR/hr measured at 1 m above ground (which are typical background values)

**contaminated gardens were based on radiation levels of 20 to 2000 uR/hr measured at 1 m above ground

TABLE 12

Summary of Total Suspended Particulate Data Collected at Station 71065, St. Joseph's Hospital, Blind River From August 1982 to October 1987

Year	No. of Samples	Annual Geometric Mean (ug/m^3)	Max. Reading (ug/m^3)	No. of Readings Above Provincial Criteria
1982	20	16	42	0
1983	45	19	48	0
1984	39	24	105	0
1985	43	20	115	0
1986	53	20	57	0
1987	47	24	64	0

Provincial Criteria: 120 ug/m^3 (24 hour period)
60 ug/m^3 (1 year geometric mean)

TABLE 13

Summary of Uranium in Total Suspended Particulate Collected at Station 71065, St. Joseph's Hospital, Blind River From August 1982 to March 1987

Year	Number of Samples	Annual Geometric Mean (ug/m^3)	Maximum Reading (ug/m^3)
1982	19	0.001	0.009
1983	47	0.001	0.005
1984	39	0.001	0.009
1985	43	0.002	0.013
1986	51	0.002	0.034
1987	47	0.001	0.007

Detection Limit for Uranium: 0.001 ug/m^3

TABLE 14

Summary of Thorium ^{228} in Total Suspended Particulate Collected at Station 71065, St. Joseph's Hospital, Blind River From August 1982 to March 1987

Year	No. of Samples	No. of Samples Below Detection Limit	No. of Samples At or Above Detection Limit
1982	20	20	0
1983	10	10	0
1984	39	39	0
1985	36	36	0
1986	49	49	0
1987	9	9	0

Detection Limit prior to Oct. 1985: 0.143 mBq/m^3
Detection Limit after Oct. 1985: 0.043 mBq/m^3

TABLE 15

Summary of Radium^{226} Analysis in Total Suspended Particulate Collected at Station 71065, St. Joseph's Hospital, Blind River From August 1982 to March 1987

Year	No. of Samples	No. of Samples Below Detection Limit	No. of Samples at or Above Detection Limit	Annual Geometric Mean (mBq/m^3)	Maximum Value (mBq/m^3)
1982	20	11	9	0.017	0.358
1983	43	32	11	0.011	0.257
1984	39	29	10	0.037	0.172
1985	43	37	6	0.032	0.160
1986	52	47	5	0.031	0.070
1987	11	10	1	0.030	0.040

Detection Limit: Prior to Dec. 1983 = 0.006 mBq/m^3
Detection Limit: After Dec. 1983 = 0.029 mBq/m

TABLE 16

Summary of Gross Alpha Analysis in Total Suspended Particulate Collected at Station 71065, St. Joseph's Hospital, Blind River From August 1982 to March 1987

Year	No. of Samples	No. of Samples Below Detection Limit	No. of Samples at or Above Detection Limit	Annual Geometric Mean (mBq/m^3)	Maximum Value (mBq/m^3)
1982	20	1	19	0.406	1.044
1983	40	1	39	0.198	1.273
1984	19	19	0	-	-
1985	43	42	1	1.359*	1.840
1986	52	45	7	1.507	2.860
1987	11	7	4	1.584	3.000

Detection Limit: Prior to Dec. 1983 = 0.006 mBq/m^3
Detection Limit: After Dec. 1983 = 1.430 mBq/m^3

* Five samples in 1985 had a detection limit of 1.14, one sample had a limit of 0.383 mBq/m^3.

TABLE 17

Summary of Gross Beta in Total Suspended Particulate Collected at Station 71065, St. Joseph's Hospital, Blind River From August 1982 to March 1987

Year	No. of Samples	No. of Samples Below Detection Limit	No. of Samples at or Above Detection Limit	Annual Geometric Mean (mBq/m^3)	Maximum Value (mBq/m^3)
1982	20	3	17	0.263	1.359
1983	40	19	21	0.039	1.430
1984	19	19	0	-	<1.430
1985	43	42	1	1.270	1.573
1986	52	32	20	1.770	7.900
1987	11	4	7	1.660	2.900

Detection Limit: Prior to Dec. 1983 = 0.006 mBq/m^3
Detection Limit: After Dec. 1983 = 1.430 mBq/m^3